AY 2007-2008

ACHIEVING U.S. ENERGY SECURITY

Energy Industry Sector Report

Seminar 8

The Industrial College of the Armed Forces
National Defense University
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ENERGY INDUSTRY STUDY 2008

ABSTRACT: The source of U.S. national security strength stems in large part from the nation's economic foundation; the ability to generate and exploit inexpensive energy underpins that strength. Therefore, the United States has a vital interest in ensuring the viability and stability of the global energy system and securing its energy security. This Industrial College of the Armed Forces Energy Industry paper analyzes the energy sector and grapples with how to maintain U.S. energy security. The paper first identifies five themes observed and emphasized from several months of study, domestic and international travel, and discussions with energy industry leaders. The paper then breaks the energy sector into two segments for detailed industry status analysis based on import dependence: transportation (heavily dependent on imports), and electricity production (mostly self-sufficient). After review of both segments, the paper concludes with the following four major policy recommendations: 1.) Price the use of fossil fuels to include externalities such as defending the energy industry, economic drain and environmental impact; 2.) Develop and foster solid working relationships with nations that broaden our energy portfolio to maintain diversity of source; 3.) Increase the U.S.' global leadership role in advancing responsible energy use to help decrease global energy demand in the short term; and 4.) Develop and promulgate a national energy strategy to reduce domestic demand, champion conservation, and reduce barriers to domestic energy production of both traditional and alternative power. The paper concludes with three essays that spotlight significant areas of interest: "Carbon Capture and Sequestration," "Water and Energy," and "Labor Shortages in Energy Fields."

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PLACES VISITED

Domestic

BP Solar, Frederick, MD
Calvert Cliffs Nuclear Power Plant, Calvert Cliffs, MD
Consol Coal Mine, Morgantown, WV
H2Gen Innovations Alexandria, VA
Mirant Coal-Powered Generating Plant, Dickerson, MD
Princeton Plasma Physics Laboratory, Princeton, NJ
Solid Waste Management Facility, Rockville, MD
Stella Group, Arlington, VA
U.S. Green Building Council, Washington, DC

International

Albian Oil Sands, Fort McMurray, Alberta, Canada
Atlantic LNG, Point Fortin, Trinidad, West Indies
Banco Nacional de Desenvolvimento Economico e Social, Rio de Janeiro, Brazil
Brazilian Petroleum, Gas, and Biofuels Institute, Rio de Janeiro, Brazil
Brazilian School of Public and Business Administration, Rio de Janeiro, Brazil
Canada Energy Pipeline Association, Calgary, Alberta, Canada
Canadian Association of Petroleum Producers, Calgary, Alberta, Canada
Chevron Burnaby Refinery, Vancouver, British Colombia, Canada
Enbridge Inc., Calgary, Alberta, Canada
Federation of Industries of the State of Rio de Janeiro, Rio, Brazil
Point Lisas Industrial Estate, Trinidad, West Indies
Quintero Bay LNG Project, Valparaiso, Chile
Rapel Dam, region of Libertador General Bernardo O'Higgins, Chile
TransCanada Corporation, Calgary, Alberta, Canada
Usina Nuclear Power Plant, Angra dos Reis, Brazil

Introduction

The source of U.S. national security strength stems in large part from the nation's economic foundation; the ability to generate and exploit inexpensive energy underpins that strength. Therefore, the United States has a vital interest in ensuring the viability and stability of the global energy system. The importance of sufficient and affordable energy to U.S. prosperity, national security, and quality of life cannot be overstated. Oil prices continue to rise, and the implications of importing approximately 60% of our petroleum become more pronounced, particularly in a time of slow economic growth accompanied by stable energy consumption. Despite recognition of the link between national security and energy in the 1970s, we remain a nation made vulnerable by conflict in oil producing nations of the world. The machinery of war as well as the American economy relies on petroleum, and our inability to escape that dependency has cost the country in financial, political, and social terms. The topic of energy has taken on strategic importance, and now frames domestic regulatory and budgetary decisions, foreign policy relationships, and military deployment strategies. As acceptance of this driving force spreads across the facets of our government, quick-fixes and political rhetoric have become the norm. What is lacking, however, is a comprehensive strategy that can carry the U.S. into the coming decades with hope that the future holds the promise of clean, plentiful energy.

Energy is not one discrete industry but comprises a wide range of distinct and sometimes disparate fields and sciences. Consequently this paper analyzes the industry by examining the various elements within two major functions of energy - those that primarily pertain to transportation and those usually used in electric power, though some fuel types can be transformed for different purposes. The main distinction is that the U.S. depends heavily on oil imports for its current transportation needs but is mostly self-sufficient in generating electricity, especially when including energy trade with Canada.

This paper will outline various themes that arose repeatedly throughout our studies and travels, followed by a summation of the current status, challenges to expanded use, and future outlook of the individual elements of both the electricity generation and transportation aspects of the energy industry. Three issues of particular interest are described in "spotlight" essays. The overarching themes and individual issues are then addressed through a set of policy prescriptions to move the U.S. toward a more secure and sustainable energy future.

Overarching Themes

All themes touch upon the interplay between energy security, the environment, and the economy. The ability of the United States to ensure an adequate supply of energy to maintain its economic strength and national security requires diversifying the sources from which the country obtains its energy. Diversification includes both resource diversity (e.g., oil, gas, renewable) and diversity of location from which the resource is obtained (e.g., Canada, Mexico, Nigeria). Throughout the course of the industry study, several themes supporting the "Security through Diversity" mantra emerged time and again.

Economy and Energy Sustain and Affect Each Other: Market Forces and Externalities

The current energy market does not incorporate in its pricing several negative externalities, including the cost of defending the global energy market and the cost of environmental degradation. The imbalance between a stressed American economy with billions of dollars flowing out of it into booming petro-economies also stands as a significant cause for concern. Instability in the Middle East costs America diplomatic, military, and economic capital. Securing shipping lanes, ports, pipelines, and providing support to governments of energy-producing states adds to the costs of fossil fuel dependency. The air and water pollution from fossil fuel emissions is causing significant harm to human, plant and animal health, and likely contributes to global warming. The challenge is finding a way to appropriately factor these costs into the price of fuel. The U.S. government must simultaneously allow the market to determine the direction of technological innovation and avoid interventions that predetermine a winner among several viable options.

U.S. Leadership and International Cooperation
As global consensus moves toward curbing greenhouse gas emission, the United States clearly has a role to play in leading the way toward environmentally and socially responsible energy use. Despite rapid improvements in efficiency, the world perceives the U.S. to be the primary culprit in environmental pollution. This weakens U.S. stature and undermines its ability to influence policy and pursue national strategic objectives. The U.S. will enhance its global standing and increase its influence to achieve other policy priorities by encouraging domestic and international energy efficiency, decreased fossil fuel use, environmental stewardship, and alternative energy sources. To directly bolster its energy security, the U.S. should reinforce its strong relationship with Canada, recognizing the unique energy trade interdependence and status as America's largest energy provider. The U.S. should strengthen ties to stable, friendly nations, without limiting or excluding trading partners to limit vulnerabilities to global energy supply.

Environment vs. Security
There is an inherent tension between strategic decisions to increase energy security and those to protect the environment. U.S. energy security today derives from ready and affordable access to fossil fuels, but the use of these fuels increase pollution and greenhouse gases that contribute to global warming that will need to be addressed in the near future. Decisions about energy use, therefore, have an environmental impact and environmental decisions affect the energy industry. Within the United States government, this tension could be addressed through clearly defined and prioritized policy objectives and a long-term regulatory agenda.

Security and Reliability of U.S. Energy Supply
While the U.S. is already tapping diverse sources of domestic energy for its electric power sector, it can ensure a more reliable supply of energy for transportation by expanding its use of domestic resources and reducing its dependence on imports of petroleum from volatile parts of the world. The U.S. can also improve the physical security of energy supply lines (e.g., Liquified Natural Gas (LNG) plants and shipping lanes). In addition, the U.S. can secure its energy for both functions by upgrading its energy infrastructure, such as pipelines and electricity transmission grid to reduce disruptions and make it more adaptable to new technologies and evolving consumer demands.

Domestic Energy Production and Conservation
The complementary piece to securing supply is leveraging resources within our own borders to ramp up domestic energy production and facilitate greater efficiency and conservation. Beyond

exploration and production of untapped sources of coal and oil, there is a need to promote research and development (R&D) to employ new forms of energy. Innovative ways to find or generate energy are constantly on the horizon, but our only true hope for short-term solutions for combating potential energy shortages comes in the form of efficiency and conservation practices. Additionally, America must also examine the need to grow more science, technology, engineering, and math (STEM) experts who can conduct the research and lay the groundwork for further innovation in the energy field.

Themes reinforced during the course of International Travel

International travel reinforced these themes. Canadian government, industry, environmental advocacy and trade groups universally underscored the benefits of energy interdependence that bind Canada and the U.S. Brazil's efforts to diversify its energy source via expansion of hydro-electricity and natural gas supply from Peru, Uruguay and Bolivia, underscore the reality of security from diversity. Also, the quest to tap and expand British Columbia's hydroelectric resources reveals the tension between energy production and use and environmental concerns. Environmentalists seek assurances that new hydroelectric projects will not harm the environment, assurances which can inhibit and sometimes prevent the projects. This tension also exists in Chile and Brazil. Chile's past dependence upon a single source of energy supply highlighted the threat that stems from lack of diversity. When Argentina turned off its supply of gas, Chile was cast into an energy crisis and a desperate struggle to diversify its energy sources while simultaneously shouldering very high energy costs. In addition, Chile's claim as a "developing country" allows it to exempt itself from meeting global emission standards, enabling energy decisions to be made based solely on price. Consequently, the U.S. can expect developing nations to pursue the cheapest available energy solutions and to not invest in expensive, leading-edge technology, letting others pay for development and its adoption. Brazil leads the world in adoption of ethanol as a transportation fuel, but more importantly, most cars sold there can burn any blend from pure gas to pure alcohol with the engine automatically adjusting to accommodate, with many adding a third option to burn natural gas. With incentives, Brazil enabled both demand and infrastructure for alternative fuels to expand simultaneously. Trinidad's position as the largest liquid natural gas (LNG) producer in the western hemisphere emphasizes the increased role of economic arbitrage on the world LNG market: with more LNG sold on the spot market, more LNG shipments change destinations while en route. Arbitrage consequently increases global security of supply, but may threaten U.S. ability to guarantee its own import supply.

Energy Industry Elements

Transport Sector

Oil

Because oil is the dominant fuel for transportation, U.S. energy security today depends heavily on its supply and affordability. The United States consumes almost one-quarter of the world's oil supply, over 20 million barrels per day in 2006.[1] Although the rate of growth of U.S. oil consumption has slowed since the mid-1970's because of conservation and fuel efficiencies, U.S. imports have climbed from 34% of oil consumption in 1973 to more than 60% today. Transportation uses over 70% of these U.S. imports.[2] Oil reserves should meet projected level of demand for 40-50 years.[3]

Challenges and Outlook: Even though oil is traded in the international marketplace, the recent surge in oil prices above $125 per barrel has recalled the specter of the early 1970's when supplies seemed limited and prices were driven by OPEC to achieve political ends. Today the growing energy demands of established and emerging economies and minimal surplus production capacity are likely the cause. For example, China's annual double-digit annual economic growth rate accounted for over half of the increase in global energy demand over the last ten years.[4] World consumption climbed from 67 million barrels per day (mbd) in 1992 to 83 mbd in 2005,[5] with projections of consumption exceeding 100 mbd within 10 years.[6] Uncertain energy supply also contributes to upward pressure on energy prices. Some analysts theorize that oil production has peaked, but long before the global oil supply is exhausted, however, remaining oil will become harder and more expensive to extract. Easily interdicted transportation of energy also adds risk to stable oil supplies.[7]

Biofuels
Biofuels, most notably corn-based ethanol, have grown significantly in the past few years as a component of U.S motor fuel consumption. Government policy has encouraged the development of this industry through tax incentives, renewable fuel standards, and import duties. There is concern that expanded use of biofuels is a major contributor to the recent increase in world grain prices. Ethanol production is expected to consume more than 4 billion bushels of corn in 2008,[8] and that by 2010, ethanol production could use approximately 36% of the U.S. corn crop.[9] Ethanol is used primarily in two types of blends with gasoline: 10% for traditional engines and 85% ethanol (E85) for specialized engines. Of the 5.4 billion gallons of U.S. ethanol produced last year, only 1% was consumed as E85 blended fuel.[10] There are only six million Flex Fuel Vehicles (FFVs) in America that can operate on E85 and other blends, compared to approximately 230 million gasoline- and diesel-fueled vehicles.[11] Production of biodiesel has risen from 0.5 million gallons in 1999[12] to 450 million gallons in 2007.[13] Only about 4 billion gallons of biodiesel can be produced annually from the entire supply of existing U.S. oilseed, animal fats, and recycled grease, less than total current U.S. production of corn-based ethanol.[14]

Challenges and Outlook: In addition to concerns regarding competition for feedstock, there are also environmental concerns associated with increased biofuel production. Greatly expanded agricultural production for biofuels will require increased water, fertilizers, and chemicals. This could result in greater soil erosion and generation of marginal land or alteration of crop rotation patterns.[15] Most owners of FFVs continue to use traditional gasoline because of the lack of infrastructure to distribute biofuels.[16] Because ethanol is produced mainly in the Midwest, ethanol is more expensive and less available on the East and West Coasts. Technological advances will enable the replacement of corn with switchgrass, algae, or other non-food feedstocks that have higher energy ratios, require less farm land, less energy to produce, and do not displace food crops. Until biofuels can compete with gasoline, however, investors may hesitate to make required investment in research and development.[17]

Agricultural Waste
Thermal depolymerization (TDP) of agricultural waste and petroleum by-products can produce light, sweet oil.[18] The cost of processing waste with TDP is comparable with current ethanol production costs, currently about $80 a barrel.[19] The advantage of TDP over ethanol is that it

does not compete with food sources for feedstocks but uses waste that would generally end up in landfills. Presently, there is only one facility creating 500 barrels per day using TDP,[20] but others plants are under construction. With the U.S. producing nearly six billion tons of agricultural waste per year, fully implementing TDP processes to recycle waste could result in production in excess of 80% of crude oil imports.[21]

Challenges and Outlook: TDP suffers from the same barriers as ethanol, primarily the lack of infrastructure to transfer waste to processing plants and then transport the oil to refineries, but can use the same petrol pipelines once refined. Once at a refinery, however, TDP-derived fuels can be transported using existing pipelines, barges, and trucks.[22] Activists for ethanol production have lobbied hard to remove TDP fuels from the list of approved biofuels that qualify for federal subsidies. TDP fuels could replace ethanol as the preferred source of alternative fuel for transport, however, because they convert well to kerosene and jet fuels[23] allowing airlines to continue using existing turbine technology. At least four more TDP plants are expected to come online before 2013.[24] This small additional production capacity will further develop the market and encourage investors to build more TDP refineries near agricultural processing plants in rural areas with large hog, chicken, or cattle populations, with pipeline spurs to large oil pipelines.

Hydrogen and Fuel Cells

Fuel cells generate electrical power by converting hydrogen via chemical reaction into electricity and water. Because of their efficiency, fuel cells have great potential for use in transportation and electrical production. Gasoline engines operate at about 15% efficiency while fuel cell engines achieve nearly 40%.[25] Fuel cells also generate no greenhouse gases whereas a gallon of gasoline produces 19 pounds of carbon dioxide.[26] Realizing the potential, the automobile industry has begun to use fuel cells in vehicles, focusing on the light yet powerful Proton Exchange Membrane (PEM) fuel cell in the range of 5-85 kilowatts.[27] PEMs require pure hydrogen and use expensive platinum as the catalyst, and cost about $4,000-$4,500 per kilowatt.

Challenges and Outlook: Fuel cells running on hydrogen hold the prospect of cheap, abundant, and clean energy for vehicles. Unfortunately, the current costs of producing fuel cells and the hydrogen feedstock are too high to compete with traditional fuels. Fuel cells cost about $300,000 per car. In addition, the hydrogen requires expensive storage technology and lacks an efficient distribution infrastructure. At best, common hydrogen use remains a future prospect, requiring cheaper capital costs and a new infrastructure. Of note, the transportation industry forecasts affordable fuel cell cars within two decades. Until then, fuel cells will continue to be used primarily in research and to fill niche roles.

Plug-In Hybrids

Plug-in Hybrid Electric Vehicles (PHEVs) utilize both gasoline and electricity. PHEVs can travel 40-60 miles on electric power before the gasoline engine must supplement. PHEV batteries, from which the vehicles draw their electrical power, need 6-9 hours to fully recharge after plugging into an outlet.[28] PHEV batteries can be recharged at night, when electrical demand and cost are lowest. The current cost of recharging a depleted 10 kilowatt per hour PHEV battery is only $1.00, which can power the vehicle for 30 miles.[29] The current cost of gasoline to power a typical vehicle that gets 20 miles per gallon would be almost $6.00 to go the same distance. In efficiency tests, PHEVs have reached 120 miles per gallon in city driving and

80 mpg on the highway.[30] PHEV versions of current hybrid vehicles, such as the Toyota Prius and Ford Escape, are undergoing fleet tests and models should be ready for mass production by 2012.[31] The Chinese carmaker BYD also expects to promote a PHEV model at the same time.[32]

Challenges and Outlook: In the short term, the electrical energy production mix is not expected to change because any increase in electricity demand will cause an increase in fossil fuel generated power. There are two primary barriers to expanded market penetration for plug-ins: battery technology and financial incentives. Current battery technology limits the electrical-only driving range of PHEVs, which lessens their advantage compared to traditional combustion engines. Hybrid vehicles already cost several thousand dollars more than their corresponding internal combustion models. The cost of PHEVs exceeds that of their hybrid counterparts by an amount that depends on the electrical-only range. Expanded adoption of PHEVs will depend on continued improvements in battery technology and reductions in the purchase price. Tax breaks and other incentives such as access to High Occupancy Vehicle (HOV) lanes and parking, similar to those offered for hybrid vehicles, would encourage demand for PHEVs. Over the longer term, battery technology should continue to improve electrical-only driving range and narrow the price gap between PHEVs and other automobiles.

Electrical Power Sector

Transmission Grid

Electric power is safe, secure, and generated from a diverse set of domestic fuels, mainly carbon-based, including coal (50% of generated power), natural gas (19%), and petroleum (3%), and an additional 28% from carbon emission-free fuels such as nuclear, hydro, and other renewables.[33] The U.S. shares an electricity market with Canada, an arrangement that provides significant economic benefits to both nations. The federal government has focused on maintaining system reliability, especially after the electricity blackout in the Northeast and Midwest in August 2003, though the recent Florida blackout in February, 2008 casts doubt on the effectiveness of these efforts. Both the Energy Policy Act of 2005 and Energy Independence and Security Act of 2007 include provisions that seek to improve the reliability and viability of the grid.

Challenges and Outlook: The entire electricity industry - generation, transmission, and distribution – is experiencing a confluence of challenges. These include a lack of a national policy on carbon emissions, long delays in approval for capital projects, and local opposition to electricity infrastructure. Collectively, these obstacles have failed to create the incentives necessary to build the national infrastructure required for sustained economic development and the transmission of environmentally friendly electricity. States have created their own unique, but nationally disjointed energy policies concerning renewable energy. The lack of a reliable and flexible national grid makes it difficult to direct electricity to the right consumers. In the absence of nationwide regulations and standards, investors continue to make piecemeal improvements to the grid instead of a modernized, expanded, and efficient national transmission system with high-capacity corridors linking the east and west coasts that would give consumers "continental" access to electricity, no matter where it is generated.[34] Bottom line, the U.S. aging electrical power grid handles a load much higher than it was originally designed for. A combination of multi-governmental approval levels, right-of-way issues, and the public's resistance to proximity to transmission infrastructure has slowed and sometimes stymied needed development. We need to find a better way ahead or risk another tree branch-induced blackout in the future. Deliberate attacks could be even more catastrophic.

Coal

About 90% of the coal demand in the U.S. is consumed in the electric power sector, providing 50% of U.S. power generation. Coal is the most plentiful and least expensive source of energy worldwide, yet the most polluting. In 2006, coal accounted for 41% of all fossil fuel-related CO_2 emissions, with oil accounting for 39% and natural gas 20%.[35] Coal provides an abundant, stable, and cheap alternative to other fossil fuels. With 200 or more years of proven reserves in the United States alone, coal is a secure energy source for the U.S., as well as China, India and much of the developed and developing world. World demand for coal is expected to rise 73% over the next ten years.[36]

Challenges and Outlook: The expanded use of coal to generate electricity in the U.S. is uncertain and financially risky because of concerns over the impact of carbon emissions and fears that this will result in high taxes or expensive regulations on coal-fired power plants. Coal will continue to play a dominant role in electrical generation worldwide because it is cheap and plentiful and does not pose the political sensitivities that nuclear power does. Carbon emissions must be reduced or eliminated for coal to remain a viable source of energy over the longer term (see following section on carbon capture and sequestration (CCS)) and a bridge to cleaner and more efficient energy sources.

Natural Gas

Almost one-fourth of total U.S. energy demand is satisfied by natural gas – a consumption of nearly 22 trillion cubic feet (tcf) in 2006. As a plentiful, energy-intense, and clean-burning fuel, natural gas has been developed for a diverse array of uses. Industry consumes the largest amount of natural gas in the U.S. for such products as fertilizers and chemicals (6.6 tcf). Substantial amounts of natural gas are utilized for electricity generation (6.2 tcf), for home heating and cooking (4.3 tcf), and in businesses (2.9 tcf). Small amounts of natural gas are used for vehicle fuel and pipeline transport.[37] Most of the U.S. supply of natural gas, approximately 18.5 tcf in 2006, comes from sources in the lower 48 states, primarily off-shore reserves in the Gulf of Mexico[38] and pipeline imports from Canada. With the expected future decline in conventional domestic supplies and growing consumption, the U.S. is projected to increase imports of LNG from under 3% in 2005 to 7.6% in 2010 and over 13% in 2015.[39] Demand for natural gas may increase with advances in hydrogen fuel cell technology, as natural gas can be used as a feedstock for production of hydrogen.

Challenges and Outlook: The market for natural gas has been largely regional up until recently because natural gas is difficult and costly to transport over long distances. With the expansion of natural gas use, however, prices are now high enough to justify the massive capital expenses needed to build the transport infrastructure to introduce greater amounts of LNG. There are presently five terminals for regasification in the United States with up to a dozen more in the planning stages. Recent increases and volatility in the price of natural gas is caused by the emergence of a global market and rising worldwide demand. Almost 60% of the world reserves of natural gas are concentrated in Russia (27.5%), Iran (16%), and Qatar (12%).[40] Of the remainder, one-quarter is located in other Persian Gulf states and another one-quarter lies in

Nigeria, Venezuela, and the Caspian Sea region. Generally speaking, unstable or unfriendly states are gaining market power. As U.S. consumption of LNG grows from sources outside of Trinidad, dependence on unpredictable suppliers will impose costs and risks similar to those generated by oil import dependence.[41] In addition, the growing importance and value of natural gas may make its infrastructure more likely targets for disruption for political or ideological ends.[42]

Nuclear Power

Nuclear power is the largest and only expandable source of emission-free low cost electricity. Fission generated 800,000 gigawatt-hours of electricity in 2007, meeting almost 20% of U.S. electricity needs.[43] The nuclear power industry has vastly improved the technology for maintaining and improving existing plants and designing new plants since the Three Mile Island and Chernobyl accidents, resulting in a world class safety record since then. The efficiency and reliability of nuclear plants has risen to record levels -- hitting 98% in August 2007.[44] U.S. government programs are exploring the use of advanced designs to promote safe and effective nuclear plant operation and secure the nuclear fuel cycle.[45]

Challenges and Outlook: Nuclear power plants face high initial capital costs, a burdensome licensing process, extended construction periods, waste management problems, and negative public sentiment. Nuclear power plants cost more per kilowatt than coal or natural gas, and take about 10-15 years to build because of the necessary construction safety and environmental impact reviews. Estimated construction costs range from $1000-$5000 per kilowatt hour (kwh) with total costs ranging from $1-$5 billion.[46] As a result, nuclear plants are considered risky investments and demand a premium on capital. The Energy Bill passed by the U.S. Congress in 2007 mitigates the financial risks by providing production credits of 1.8 cents/kwh for the first three years of operation to encourage new nuclear reactor construction.[47] Since 1987, the variable cost of producing electricity has decreased from 3.63 cents/kwh to 1.68 cents/kwh in 2004 and plant availability has increased from 67% to over 90%. Even with streamlined licensing procedures, however, it can take up to three years to obtain an operating permit. If a license is approved by the Nuclear Regulatory Commission in 2008, construction could begin in 2010 for a new plant to come on line with commercial operations in 2016.[48]

Long-term storage of nuclear waste is another challenge. By 2057, nuclear waste will have been accumulating at power plant sites for 100 years – much longer than originally intended. New technologies may soon be available to better utilize spent nuclear fuel and reduce the volume of waste. Nevertheless, some volume of waste will require safe and secure storage. Decades of industry-funded research has supported deep geologic disposal, but the process for approving a geologic site is problematic.[49] The Yucca Mountain disposal site, for example, has been under consideration for two decades and even if approved today would not open until 2015.

Renewables

Biomass, Landfill Gas, and Municipal Waste

Biomass includes a broad category of fuel sources that can be harvested indefinitely.[50] "The United States is currently the largest producer of electricity from biomass, with over half of the world's installed capacity -- over 7,800 megawatts at more than 350 locations. However, this meets just 1% of total U.S. electricity generation demand."[51] "Using bioenergy does not increase atmospheric carbon dioxide, one of the greenhouse gases considered to be the major cause of global warming. In fact, it can actually decrease the amount of methane – another more potent greenhouse gas – which is given off by decaying plant matter."[52] Biomass is the cheapest of the renewable energy sources used for generating electricity.[53] Biomass fuels are also bio-degradable and non-toxic, making them safer when used near population centers.[54] There are over 2,300 currently operating or recently closed landfills in the United States. Of these, about 445 are used for energy projects and another 535 landfills are good candidates for future projects.[55] The EPA estimates that landfills could produce enough electricity to power more than 808,000 homes.[56] Municipal solid wastes are another biomass fuel source utilized in the United States. "In 2007, 87 plants operate in 25 states and process 28.7 million tons of trash. Electric generating capacity is estimated at 2,720 megawatts."[57]

Challenges and Outlook: To be a practical source of fuel, biomass must be present in sufficient volume to meet the demands for electrical generation. Most biomass products are bulky and have a low-energy density. It is not economical to transport them long distances without further processing.[58] Currently, biomass is predominantly burned as a direct-fire source of fuel to produce steam for electrical generation. Biomass gasifiers convert the biomass into flammable gas that can be used as a cleaner fuel source.[59] At present, most biomass materials are considered waste products and are inexpensive. Also, the development of cellulosic ethanol technologies will increase competition for biomass materials.[60] Increased cost for biomass materials may adversely impact the cost effectiveness of biomass fueled power plants. Increased costs of fossil fuels make biomass fuels a competitive and viable alternative. Existing technologies have demonstrated that small scale power generation is economically feasible and provides environmental benefits. In the longer term, biomass fuels for electrical generation fit well into a distributive energy infrastructure using smaller generating units located near the point of consumption.[61]

Wind

Wind is the fastest growing alternative energy source in the U.S., providing 30% of the United States' new energy generation in 2007. General Electric announced in early 2008 that production of its most popular wind turbine had increased by 500% since 2004, with a 15-month backorder waiting to be filled. It took G.E. almost 10 years to sell 5,000 of its best selling 1.5 megawatt turbines world-wide through 2006, but it has already sold 3,000 in 2007-08. Wind power generation capability has grown by 100% in just the last two years, to 16,818 megawatts in 34 states in 2007. By the end of 2008, wind power is projected by the Energy Information Administration to supply 48 billion kilowatt hours of electricity, meeting more than 1% of U.S. demand. The U.S. Department of Energy reported that wind power could provide 20% of U.S. electricity by 2030.[62]

Challenges and Outlook: Expanded use of wind power will depend on continued Production Tax Credits (PTC), technology and electrical grid improvements, as well as public acceptance of windmills within the line of sight. The PTC provides a 2 cent/kwh subsidy to power companies for each kwh produced by wind (and other renewables). Imposition of a tax on carbon would also make wind power more marketable. Today's wind turbines are twice as efficient as those produced just five years ago, and DOE projects that with more refinement and blade improvements, efficiencies will double again by 2017. There is a short-term supply constraint, with turbine, blade and tower firms scrambling to increase production, but this should be resolved with expanded investment. Over the longer term, the use of wind power could rise in popularity as electricity competes with fossil fuel in transportation and home owners begin to install and sell distributed power to the grid. The DOE reported that 7.6 *gigatons* of CO_2 emissions could be avoided by 2030 if wind energy achieves 20% of the nation's electric power mix.

Solar

In a year, the earth receives almost 10 times as much energy from sunlight as from all other sources combined.[63] Even so, solar energy today provides less than 0.1% of the electricity in the United States. Currently, the principal markets for solar energy are residential and commercial electric utilities that use photovoltaic and concentrating solar technology.[64] The two primary ways to capture sunlight for energy are from photovoltaic cells and solar thermal panels. Since the late 90's, the United States has lost its dominance in the solar energy industry to Japan and Germany. Japan granted 50% cash subsidies for grid-connected residential systems while Germany encouraged solar installations by guaranteeing low electricity prices, thus increasing economies of scale and reducing solar technology costs. The global solar market is now a multi-billion dollar industry providing cost effective energy to millions world-wide.

Challenges and Outlook: To date, the price of solar technology appears to be the largest impediment to creating sustainable momentum towards its use as a substitute for coal and gas-fired electricity in the United States. Uniform net metering and interconnection standards are also necessary to increase the use of solar energy. As shown by the solar initiatives in Japan and Germany, the global solar industry could achieve commercial success in the next 30 years with continued high natural gas prices and concerns about the use of coal and nuclear power. The solar market is expected to continue its rapid growth through the next decade reaching upwards of 6,000 megawatts of installed capacity by 2010. Grid-tied residential and commercial markets, where consumers may sell unused or generated electricity to the grid, are expected to drive growth of this sector barring any public objection to widespread placement of panels. The DOE projects that with relatively small investments in research and development and other incentives, photovoltaics could displace 10-25% of all new sources of electricity by 2015 and up to 40% of new capacity by 2030.[65]

Hydroelectricity

Hydroelectric power represents 71% of renewable electricity generation in the U.S. though its role may not increase significantly in the coming years.[66] During the current performance period, capacity of hydroelectric power is expected to remain just under 100,000 megawatts. Most sites appropriate for large dams have been developed, and concerns from the environmental community are slowing approval processes.[67] Potential changes in weather patterns (e.g., global warming) may alter the favorability of hydropower. Reduced water flow from rainfall, reduced water intake from water sheds, and decreased water intake from snow melts, specifically in the western portion of the United States, may reduce the viability or hydroelectric power production.[68] In addition, these changes may exacerbate the impacts to native fish species. Technologies are being developed that can expand the use of hydropower in the future. In-stream power production uses turbines in liquid flows to generate electricity. This technology can be used in streams as well as pipelines carrying liquids from one part of the United States to the other. Tidal technologies seek to capture the power of incoming and outgoing tides. This technology works similarly to that of in-stream using a turbine under the water to capture the energy produced by the flowing tide. Wave technologies utilize the power of ocean waves and water surges to force air through a confined space, spinning a turbine to produce power. Once the technology is feasible and the costs to generate power viable, tides and waves could provide reliable electricity for years without disruption – a truly renewable energy.

Challenges and Outlook: In the next three years, hydropower generation will not increase significantly. The limitation in suitable dam sites in the United States makes dam construction difficult especially when coupled with the environmental challenges associated with licensing of new projects. There are, however, potential opportunities for the generation of in-stream, tidal, and wave power generation in the future. With continued research and testing and the successful refinement and adaptation of new technologies, hydroelectricity generated from streams, tides, and waves could become a significant contributor to the electricity supply of the United States.

Policy Recommendations

In the interest of national security, we must address both the supply of energy for the long-term (10-50 years) and the demand for energy in the short term (0-10 years). The following policy recommendations address both concerns and stem from the themes revealed over the course of this study.

Recommendation 1—Adopt a long-term strategy to increase supply by incentivizing development of alternate fuels and understanding real costs (energy asset protection, environmental degradation, etc.):

- **Incentivizes an improved infrastructure for non-traditional fuels.**
- **Incentivizes an improved infrastructure for renewable sources of power (e.g., net metering capabilities, regional grid interconnections, pipelines able to transport biofuels, distribution of Hydrogen for fuel cells).**
- **Incentivizes technologies that enable "better" use of traditional electricity, such as carbon capture and storage and clean coal technologies, removal of barriers to nuclear power, and development of a flexible, national grid system.**
- **Subsidizes regional infrastructure development as test cases.**

This bolsters U.S. national security by promoting development of alternatives and better use of current fuels to increase energy supply. The first step increases taxes on fossil fuel use and imports to capture their true cost to society. With the current high price of fossil fuels, increased taxes may be unfeasible politically and could hurt the U.S. economy. Taxes could be imposed provisionally, however, to keep prices from falling below a certain level. This would maintain market incentives to encourage innovation and development of alternative energy. Subsidies should also be used in the form of tax breaks and grants to encourage research and development. Subsidies can also promote alternative energy and related regional infrastructure for its distribution, such as in the Midwest for ethanol and the populated Northeast for hydrogen. By adopting these strategies, the U.S. government would not pick an "ideal solution" to sustainable energy security but foster entrepreneurial motivation by merely establishing the true price of fossil fuel energy through taxes and subsidies. Finally, energy taxes that capture externalities establish costs that suppliers and consumers can plan and invest for in the long-term; predictability is a key element in economic planning in the private sector.[69] The higher prices imposed by accounting for these negative externalities, however, will pose additional financial burdens on the economy. Higher energy costs result in higher production and transportation costs, reducing the competitiveness of U.S. goods on the world market in the short-term.

Recommendation 2—Adopt a long-term strategy to increase import supply by improving relationships with other nations to broaden the U.S. energy portfolio:

- **Strengthen unique inter-dependent energy relationship with Canada through cross border energy initiatives.**
- **Increase imports from sources least vulnerable to economic arbitrage.**
- **Approve the production and transport of oil and gas discoveries in Alaska and Canada for consumption in the continental U.S.**

National security benefits from large and diverse number of suppliers. A key threat to supply stems from political desire to deny energy export and from arbitrage that diverts supply. Proximal, physical links limit this threat. Nations that border the U.S. or that can be physically linked to U.S. markets via pipe or transmission lines offer security via integrated energy networks that benefit all nations involved. When the best customer lies at the end of a pipeline, the threat of that energy supply being diverted away from the U.S. (i.e., arbitrage) is mitigated. The U.S. government should take every step to keep Canadian suppliers tightly intertwined with U.S. energy markets while increasing ties with Mexico. The prospect of pipelines from Latin America through Mexico or under the Gulf may be too expensive and complicated for contemplation, but if future developments allow, they should be encouraged.

Recommendation 3—Adopt long-term strategy to improve U.S. global leadership and advance more responsible energy use though efficiency, conservation, and improved environmental practices:

- **Develop and disseminate research findings on clean and renewable technologies.**
- **Coordinate international forums and multilateral policy dialogues to generate enthusiasm and cooperation for the adoption of alternative energy, conservation, and energy efficiency practices.**
- **Require energy efficient methods and appliances in all federal government building and organize a whole-of-government conservation campaign to save electricity.**
- **Require the federal government vehicle fleet to have compressed natural gas or hybrid engines.**
- **Promote Science, Technology, Engineering, and Math (STEM) opportunities for secondary and post-secondary students.**
- **Fund and implement alternative energy and conservation provisions already existing in enacted legislation (e.g., Energy Independence and Security Act of 2007).**

National security benefits from reduced stress on the global energy supply, so reducing global demand carries significant strategic weight. Developed countries asked to devote more resources to carbon reduction measures fear they will find themselves at a trade disadvantage relative to those countries that are given leeway due to their developing status. While no one expects the

United States to sacrifice its national treasure or well-being to fund greenhouse gas reductions in the developing world, we believe the U.S. does have a responsibility to continue to search for economic ways to reduce our own emissions, and then be willing to share that technology with developing nations. Moreover, demonstrating that efficient and environmentally sound energy use bolsters a company's and a nation's prosperity will go a long way toward encouraging responsible use on a global scale. International forums for cleaner energy sources should be supported (for example, living up to our promises regarding funding for the International Thermonuclear Experimental Reactor (ITER)), and long term funding for energy research and development should become a assured portion of the annual budget, protected from political "horse-trading."

Recommendation 4—Develop an immediate strategy to reduce domestic demand of non-renewable energy sources:

- **Reduce the amount of oil used for transportation through increasingly stringent Corporate Average Fuel Economy (CAFE) standards, greater incentives for hybrids or flexible fuel vehicle production and purchase, hydrogen fuel cell production (long term).**
- **Emphasize oil conservation and fossil fuel efficiency measures, such as reducing the speed limit on national highways and expanding support for public transport.**
- **Encourage smart consumption through consumer education.**
- **Set a well-defined, prioritized regulatory agenda for the next 20 years to reduce investment uncertainty.**
- **Give Federal Energy Regulatory Commission (FERC) the ability to use existing Rights of Way for transmission lines.**
- **Reduce barriers to alternative energy, such as opening offshore waters for wind and hydro technology.**
- **Provide corporate tax deductions for meeting advanced office and industrial efficiency in building design and water and power use.**
- **Loosen restrictions on new drilling off the coasts of California, Florida, and other states with current prohibitions.**
- **Boost subsidies for research, development, and generation of wind, solar, small hydropower, hydrogen, and geothermal energy.**

Many of the problems surrounding the issue of national energy security follow from the lack of or ambiguous guidance regarding what the United States plans to do in the coming years. As was mentioned several times in this paper, entities that have the desire and resources to invest in emerging technologies are not willing to do so given uncertainties in the regulatory or political process. The future of the United States depends upon an adequate energy supply, and should rise above the changing politics of four to eight year Administrations. A team of nonpartisan experts should be convened to consolidate the data from recent public and private sector studies and identify the priorities of the nation in a long term energy strategy that balances the need for energy security with that of environmental stewardship and economic growth.

Conclusion

U.S. national security requires a reliable and sustainable energy supply, which means avoiding dependence on a concentrated number of fuels and on less stable sources for oil imports. This means expanding and utilizing domestic resources for both transportation and the electric power sector by upgrading and expanding the domestic energy infrastructure for transmission of electricity and liquid fuels. The U.S. should also adopt conservation habits and use energy and power efficiently, as well as developing alternative energy sources, encouraging innovation and change through market incentives that guide but do not dictate. The U.S. government must demonstrate leadership and political will to ease the transition to a future driven by renewable energy. Because national security begins on foreign shores, the U.S. must foster strong international relations with all energy producing and consuming countries, model effective national consumption and conservation practices, and lead global efforts in research and development and the dissemination of technology that can accelerate the adjustment to a next generation that is sustainable and secure.

Energy Spotlight Issue Essays

Carbon Capture and Sequestration

Coal is the most plentiful and least expensive source of energy worldwide. Not surprisingly, in 2006 coal accounted for 41% of all fossil fuel related CO_2 emissions with oil accounting for 39% and natural gas 20%.[70] Both scientists and the public have begun to accept the role anthropogenic carbon emissions play in global climate change. Because of its availability and affordability, coal will remain a critical fuel for the foreseeable future. The full-scale implementation of nascent carbon capture and storage (CCS) technology must be pursued in order that coal remains a viable energy source in a carbon-constrained world. CCS is actually a family of technologies, none of which are new. Carbon dioxide is an important industrial gas and has been produced and used for a variety of processes including injection into the ground to enhance oil production for many years.[71] The challenge for the future is adapting the technology to the power generation industry.

The Next Step for CCS Technology. The critical next step is scaling up the technology to address the massive volume of CO_2 emitted daily from coal-fired power plants. To give perspective to the task, if just 60% of the daily CO_2 production from U.S. coal-fired power plants were captured and compressed, it would amount to approximately 20 million barrels of oil—the same quantity as our daily oil consumption.[72] The infrastructure required to manage this volume of material is immense.

For capture, the focus must be on power plant technology improvement. The MIT Coal Study suggests that it is too soon to focus on a single plant design. They recommend both Pulverized Coal (PC) and Integrated Gas Combined Cycle (IGCC) system research as well as research on oxygen separation technology. For PC they recommend focus on supercritical technology and for IGCC they recommend attention to plant operability and reliability.[73]

For storage, the first step is a national scale capacity assessment.[74] In addition to the capacity assessment, large scale storage must be demonstrated in a variety of geological formations. Carefully executed demonstrations will provide the necessary information both for the technical scale up of the operation as well as adequate information for regulatory agencies to develop final rules for the process. The demonstrations will also benefit the development of business cases for industry investment and benefit the public by proving the safety of the process.[75]

The Next Step for CCS Policy. The most significant issue impacting the future of CCS is the U.S. position on formal controls for carbon emissions. The electrical power production industry is delaying or cancelling construction of coal-fired plants while they wait to see how the U.S. will proceed. For CCS, the choice of either a carbon tax scheme or a cap-and-trade program is immaterial; the industry simply needs direction. In addition to moving the power production industry forward, clear direction will allow the U.S. to move beyond the controversy surrounding the Kyoto protocol and return to a world-leading role in climate change. The second level policy challenge is the development of a comprehensive and consistent regulatory structure.[76] Because the technology scale up requires a huge investment, regulatory clarity will translate into significant reductions in cost over the life of the projects. Further, the more quickly regulatory clarity is achieved, the more likely private industry will fund technology development.

Regulatory clarity can be further defined for each of the three CCS processes. For transportation, the rules governing interstate transportation via pipeline must be confirmed. Because CO_2 can be a hazardous gas, liability rules for transportation must be addressed as well. The current scheme in place for natural gas transportation should be modified to include CO_2.

For storage, a series of regulatory issues must be resolved. First, the Environmental Protection Agency (EPA) must finalize regulations governing the injection of CO_2 for long term geologic storage. The EPA has indicated they are likely to regulate the injection of the CO_2 under the Underground Injection Control program of the Safe Drinking Water Act; however, no final rules have been proposed.[77] Second, long-term liability for the storage sites once injection is complete must be established. The National Petroleum Council (NPC) report suggests indemnification of the operators may be necessary in order to encourage investment in CCS technology.[78] Both the EPA and the states that have primacy in environmental regulation must learn from their experiences with hazardous waste liability from Resource Conservation and Recovery Act (RCRA) and Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) over the past 30 years.[79] Finally, the Carbon Sequestration Leadership Forum sponsored by the International Energy Agency identified resolving potential jurisdictional conflicts between federal and state governments in both regulation and permitting for storage projects as one of their top five issues in a 2006 workshop.[80] Regulatory clarity for the capture phase of the process is linked to the same set of permitting and liability concerns as the storage phase. More importantly though, progress on capture technology hinges on clarity of the future role of public funding for technology development.

Recommendations for the Way Ahead. Due to its abundance, the existing infrastructure investment, and the long-term cost implications, the future use of coal for power production is a critical strategic issue for the U.S. CCS is the critical link between the future coal use and manageable climate change. Thankfully, because the key processes of CCS are not new, scientists agree the prospect of CCS is not technologically limited. Rather the key issue is scaling the technology to match the CO_2 emissions at a reasonable cost. To achieve this outcome, the U.S. must find the political will to address climate change and acknowledge that managing emissions from coal fired power plants is both a near term imperative and a long term strategic requirement for national prosperity. Moreover, the ability to use electricity from coal-fired power plants is essential to future hydrogen based transportation strategies to reduce CO_2 from vehicle emissions. The following four recommendations are essential to ensuring CCS facilitates the long term use of coal.

Strengthen the Strategic Plan. Government investment in demonstrating and refining CCS technology requires a multi-year investment plan. The current restructuring of the FutureGen project indicates the DOE lacks a strategy that understands the state of the technology and is sufficient to overcome the cost fluctuations associated with large infrastructure investments.[81] The department must work with the Congress to move CCS technology forward with a multi-year program funding commitment.

Leverage Public-Private Partnerships. Because electrical power production is a lucrative commercial industry, the federal government should not have to fund full-scale development of CCS. The public-private partnership formed with FutureGen recently broke down. Efforts to renegotiate the cost sharing arrangement failed.[82] The FutureGen Alliance expressed concern about the contracting rules encumbering the process[83] and the MIT Study also expressed concern about the potential that federal procurement rules would jeopardize the project.[84] DOE must resolve these issues and work with Congress to remove legal obstacles to energize the market.

Link Carbon Management to Rapid Technology Integration. Congress is considering a number of options for carbon management. These legislative options include both carbon tax strategies and cap-and-trade strategies. As the Congress moves forward, they must structure the law to incentivize rapid deployment of CCS technology. One strategy proposed in the MIT study worth immediate adoption is a guaranteed government purchase price for captured CO_2 from commercial scale power production plants.[85] The price would be set to incentivize rapid inclusion of capture technologies.

Clarify Risk Management Structure. Finally, DOE, EPA, the various state regulatory agencies and the power production industry must develop a clear regulatory agenda to reduce the risks associated with long-term geologic storage of CO_2. Aggressive efforts to clarify risks will encourage investment and ultimately reduce the cost to implement CCS at the scale necessary to impact climate change.

-By David Crow

Water and Energy

The water energy nexus poses serious national security concerns as globalization broadens development and increases the worldwide demand for both energy and water. The basic relationship between energy and water is that energy is required for the production of potable water and water is required to produce energy. While the international community has focused its attention on the environmental impact of greenhouse gases (GHG), it needs to heighten the awareness and develop global policies to deal with the increased competition for the limited freshwater resource. These policies need to balance the desire for clean energy with the water demands—"dry energy".

The Growing Energy and Water Demand. While the global supply of freshwater is a finite quantity, the demand for this resource continues to increase. The U.S. Census Bureau projects that the current world population of 6 billion people will grow to 9 billion by 2043.[86] This 50% increase in the world population, combined with continued economic development, leads to the projection of an overwhelming increase in the global energy demand. The Energy Information Administration projects energy consumption to increase 57% by 2030, a full 13 years prior to the population reaching 9 billion people.[87]

National Security and the Water Resource. The limited supply of freshwater in the face of a growing demand for water resources is a potential catalyst for future conflicts. To date, no modern wars have been fought over water sources; in fact the last war attributed to water rights was waged 4,500 years ago.[88] Nonetheless, the potential for conflict increases as the demands increase on this limited resource. USAID reports that of the 48 countries projected to have severe water shortages by 2025, 40 of them are located in the Middle East and Africa.[89] Additionally, a UN report predicted that water issues may be the leading cause of conflict in Africa in the next 25 years.[90] Some experts see water becoming the new oil, with competition and conflicts arising over water rights just as they have over oil resources.[91]

Water sources do not recognize international boundaries; a reality that can create tension over water rights. Approximately 260 rivers, providing 60% of the world's freshwater supply, are shared by two or more countries.[92] As rivers and lakes cross borders, states compete for access to the water. Countries situated downstream are at the mercy of its neighboring upstream states that hold the source and can control the flow of water. Historically, potential conflicts caused by water extractions have been handled on a regional basis, but increased energy demands may be more difficult to resolve.

Public Policy for the Energy-Water Nexus. The water-energy nexus takes on greater import as energy security and global development move to the forefront of the national security debate. The 2006 National Security Strategy identifies "enhancing energy security and clean development" and "opening, integrating and diversifying energy markets to ensure energy independence" as two components of the plan for global development.[93] Yet, clean development is a code word for considering GHGs and their environmental impact. The one-issue focus neglects the very critical role that water usage plays in energy development.

The Energy-Water Nexus as an International Issue. In contrast to the global effort to deal with climate change, the nexus of energy and water is absent from the international discussion. Global warming has created an international consensus to address the impact of GHG emissions on the environment. The focus of water discussions has been on a clean water source for sustainable development. The UN Millennium Development Goal calls for halving the proportion of people without sustainable access to safe drinking water and sanitation by 2015.[94] Much of the focus on economic development is in Africa and the Middle East, two regions that face a natural water shortage. Saudi Arabia has pursued large desalination plants to produce potable water for its population. However effective this effort is, it exemplifies the tenuous balance between water consumption and energy production. Desalination plants require large amounts of energy and therefore produce GHG emissions to produce potable water for the population.

The international community is slowly becoming aware of the link between energy and water. The Fourth World Water Forum, the latest in a series of 10 international conferences pertaining to water since 1977, mentioned the water-energy linkage in a summary of its report but it did not address the need to balance GHG emissions of energy sources with the impact on the water supply.[95] The U.S. State Department, UN agencies and several donor countries established the Global Alliance for Water Security focused on development and assistance in priority regions.[96] As a result of this alliance, USAID India has become the first U.S. mission to specifically address the water-energy nexus in context with its development assistance in the country.[97]

Policy Recommendations. The United States must increase its awareness of the water-energy nexus and apply its impacts to future policy proposals. Instead of focusing solely on clean energy, there has to be an equal emphasis on dry energy. Much like the media campaign trumpeting the need for clean energy, the U.S. needs a similar campaign addressing the need for dry energy.

In addition to enhanced education, the cost benefit analysis of the tradeoffs inherent in the water energy nexus must be considered in research of alternative and renewable fuels, with a cost benefit analysis between GHG emissions and the impact on water. The focus on cutting oil dependency at all costs is not weighed against the costs of water usage today. Researchers and policy makers must consider the viability of alternatives in light of the water demands and energy required to produce it. Research on more effective cooling systems for steam driven turbines would also pay major dividends in decreasing water usage. Additionally, extraction methods for oil shale, oil sands and coal bed methane need to be refined to decrease the water impact as well as the GHG.

The U.S. must continue to expand its contributions to the Global Alliance for Water Security and apply the lessons learned from the USAID India experience to its other diplomatic missions. Additionally, the U.S. should be an advocate for adding the water energy nexus to the agenda at regional forums. The U.S. should push the UN so that the organization and its partners in human development manage the trade-offs between GHG emissions and water demands and impacts. As interrelated issues, water and energy must be dealt with concurrently; otherwise the unintended consequence of a too narrow focus on GHG will create a worldwide shortage of freshwater. There is no silver bullet answer to dealing with the water energy nexus, but rather the issue requires a reasoned balance between water, energy and global development.

-By Chris Kulas

Labor Shortages in Energy Fields

The shortage of qualified workers across the spectrum of the energy industry has reached an all time high in the United States. Currently, there is a shortage of skilled labor within the production and power generation, oil and gas exploration, and chemical industries.[98]

Compounding this setback is the extremely high number of retirements projected over the next decade.[99] The energy industry workforce shortage threatens our energy security and demands serious attention.

Challenges

Finding a viable solution to our energy labor shortage is clearly a widespread problem across the energy spectrum. People will be the most important national resource in future oil and gas development.[100] Results from a survey conducted by the Center for Energy Workforce Development (CEWD) reported that by 2012 more than half of all non-nuclear power plant operators may need to be replaced due to projected retirements. A reported 52% of generation technicians will reach retirement eligibility.[101]

The petroleum industry workforce experienced a lack of hiring following the 1980s which resulted in the current staff being on a downhill slide toward retirement within the next decade. One of the biggest obstacles facing the petroleum industry is the shortage of qualified engineers. Without sufficient personnel with specialist knowledge of disciplines such as enhanced recovery and process and seismic technology, the industry will be unable to serve the sheer number of ongoing and future projects.

Canada is currently the largest provider of U.S. crude oil, providing 16% of its total oil. Canada is projecting the highest percentage of retirements, with about 20% of the workforce retiring over the next 10 years.[102] Current skilled labor shortages threaten the success of extracting this critical source of energy.

The coal industry generates over 50% of our electricity in the United States, however they have also suffered from shortages in labor supply. CONSOL Energy is reported as the second largest coal company in revenues, nevertheless their employees have gone from 25,000 in 1974 with 56 mines down to 7,200 employees in 17 mines.[103]

Similar to the other power generation industries, the nuclear industry will experience 26% of their engineers retiring within the next 5 years and more than half will be eligible within 10 years. The average nuclear engineer's age is 48 and many engineers in the nuclear industry are 55 or older.[104] There is also a specific skill shortage in qualified radiation protection professionals. The Health Physics Society (HPS) has projected a near-term impact that will steadily worsen.[105] Present demand for these workers is approximately 130% of supply. In 10 years, demand will be more than double the supply of radiation protection professionals.

Renewable energy is not immune to labor shortages. According to the EIA 2006 statistics, renewable energy holds the smallest percentage of energy consumption in the nation's energy supply at 7%.[106] With all the increase interest in using cleaner energy and long-term environmental impacts, it is only a matter of time before we see renewable energy take on a larger role in the energy industry. It is estimated that by 2030 nearly a half-million new jobs could be created in the wind industry. The solar industry was worth about $200 million five years ago and in 2007 it topped $2 billion.[107] Given this growth, the need for more labor and federal money for job-training programs for workers to become skilled in green industries is increasing.

The Way Ahead
It will take every energy industry using a combination of education, training, promoting energy security and all the economic and political support it can garner. Thought should be given to a coordinated national strategy with industry partnering with government to unite multinational energy companies, educators and professionals to recruit, train and retain energy professionals.

In recent years, news of this energy workforce shortage has piqued the interest of Congress. The Senate Committee on Energy and Natural Resources has reported that workforce shortages could cause significant delays in the delivery of energy, including oil and gas. Senator Domenici has said that the key to meeting these challenges over the long term is through education and development of our young people and more support for Career and Technical Education (CTE) schools.

Oil and gas companies are becoming increasingly responsive to their employees and are developing creative solutions to meet individual needs to retain talent. Some companies are using aggressive compensation plans, direct access to company leadership and flexible work arrangements. In order to retain critical knowledge, some creative employers are encouraging older employees to work part-time or consult, setting up formal mentoring programs for knowledge transfer and offering phased retirement to critical employees.

Industry has begun partnering with many two year colleges to promote degrees in Applied Science in Process Technology which prepares students to enter the market as entry level process operators in the oil and gas exploration/production energy sector. ExxonMobil, Georgia-Gulf and Dow Chemical are just a few who have benefited from their direct involvement with educating the next generation of technicians.

Promoting the energy industry through community outreach, presentations at high schools, technical schools, colleges and military outplacement agencies will enhance the possibility of reaching potential candidates. Participating in mentoring programs will allow potential recruits to benefit from learning from veteran journeymen who can transfer their wealth of knowledge and shorten the learning curve.

As the energy industry and government scramble to find ways to address this issue of workforce shortage and stabilize potential disruption to our energy security, it is encouraging to see initiatives start to develop. The U.S. Labor Department, Department of Energy and the energy industry have recently partnered to develop accelerated training and apprenticeship programs at U.S universities and community colleges to steer more candidates to engineering and science disciplines.

Finding the right balance of policy and government intervention is difficult to do. Our future depends on exceptional leadership direction, political commitment and creativity to turn this industry around.

-By Joanne Bryant

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